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AUTHOR Linton, M. J.; And Others
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ABSTRACT

Use of a computer programming language in problem-solving activities provides an opportunity to examine how young children use a restricted set of language primitives. The generation, and execution of computer instructions was used as a verification stage in the problem-solution process. The metric is intended to provide a descriptive classification, and thus allow simple comparisons of productions. Procedures are assigned a cumulative score for: (1) lines of code in the procedure; (2) unique Logo operators; (3) arithmetic operators; and (4) correct procedure definition. When appropriate, points are subtracted for failure to use either primitive operators that simplify structure or arithmetic operators that reduce procedure length. The data were collected during twenty 1.5-hour weekly sessions. Twelve children (age 7 years 8 months) participated as volunteers. The children were selected unsystematically from a larger group who had participated in a "writing workshop" program, where each child had at least six hours of use of a word processor. Scores were derived for all procedures generated in the workshop. The relation between these scores and other measures of performance, specifically, with a Piagetian measure of horizontal/vertical coordination are discussed. In addition, documentation of methodology and the support materials are presented. (Author/PK)

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A Classification Metric for Computer Procedures In a Structured Educational Environment

M. J. Linton
C. A. Cameron
A. K. Hunt

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Paper presented at the Annual Meeting of the Canadian Psychological Association (Vancouver, BC, June, 1987).

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A classification metric for computer procedures in a structured educational environment

M. J. Linton, C. A. Cameron, A. K. Hunt
The University of New Brunswick

ABSTRACT

The use of a computer programming language in problem-solving activities provides an opportunity to examine how young children use a restricted set of language primitives. We controlled the development of Logo procedures by imposing a set of rules of work. We encouraged the decomposition of a stated goal into a set of previously developed logical notions and, provided a number of practical strategies and physical aids to this end. The generation, and execution of computer instructions was used as a verification stage in the problem-solution process.

The metric is intended to provide a descriptive classification, and thus allow simple comparisons of productions. Procedures are assigned a cumulative score for, a) lines of code in the procedure, b) unique Logo operators, c) arithmetic operators and, d) correct procedure definition. When appropriate, points are subtracted for failure to use either primitive operators that simplify structure or arithmetic operators that reduce procedure length.

The data were collected during twenty 1-1/2 hour, weekly sessions during 1984-85. Twelve children (age 7 years 8 months) participated as volunteers. The children were selected unsystematically from a larger group (n=32) who had participated in a "writing workshop" program, where each child had at least 6 hours of use of a word processor.

Scores were derived for all procedures generated in the workshop. We will discuss the relation between these scores and other measures of performance, specifically, with a Piagetian measure of horizontal/vertical coordination. In addition, documentation of our methodology and the support materials, will be presented.

Background for the research

The use of the Logo computer language with children is seen by some as a vehicle for learning about mathematics and problem-solving. Papert (1980) has argued that his computer language can facilitate the development of "powerful ideas" in children, when it is used as a medium of discovery and invention.

The use of Logo in the classroom has been observed rather extensively during the last half-decade. In particular, Noss (1984) gives detailed descriptions of examples of the work of children performed over a 1 year period. Hillel (1984) has made a more detailed study of how 16 children were able to work in a laboratory environment

We are currently conducting a three year longitudinal research programme in which we are examining development in the primary school years. We are interested in the development of reading and writing abilities and, in the development of problem-solving skills

SE 048 906

Poster, CPA, June 1987 Vancouver

The research reported here is part of a "pilot" project that we conducted in the laboratory as preparation for our classroom work. During the pilot research we attempted to determine, for ourselves, the practical limits to the usefulness of Logo as an instructional vehicle. In addition, we developed a methodology within which we could expect individual children to derive practical benefit from using Logo. Finally, we were interested to see exactly how primary-school children would perform when provided with what we thought to be an optimally supportive, that is, structured, working environment.

The Mathematics Workshop

During the first workshop session, the research-teacher (AKH) demonstrated the steps in the process of using a computer to draw a geometrical shape. First, the drawing technique used in Logo was demonstrated on a blackboard. Next, the teacher elicited commands for a square from the children. These commands were formalized and written on the blackboard as a Logo procedure. Then, at a computer, instructions already written for square were examined and compared to those on the blackboard. Finally the procedure was executed, to verify that it drew a square on the computer monitor.

The children were then asked to re-create the design steps in the production of a square for themselves, beginning with a drawing of the object and ending with a verification of a Logo procedure.

During subsequent sessions, in order to provide some experience with this procedure-production process, we guided the development of several shapes. Our goal was to provide "building blocks" that could be incorporated into subsequent projects. After a general purpose procedure for a series of stacked squares was introduced, individuals were encouraged to select design goals for themselves using the building blocks already developed.

A total of five microcomputers were available for use. Along with the research-teacher, two assistants were available to provide assistance to the children and to document their activities.

Design Selection

At the beginning of each project, the children were required to provide a description of what they intended to draw. This description was translated into a sketch that was usually a representation of how the finished product would look on a computer screen. Figure 1 is an example of a design sketch.

Initially, we encouraged the children to use the objects for which they had already written procedures, namely, "squares" and "stacks" and thus their designs were influenced by the constraints imposed by these shapes. When a demand for other shapes developed we provided procedures for circle and triangle. These new procedures were presented as objects with defined start/end positions but their internal operation was not derived.

Virtually all of the procedures written by the children used a place-holding name for the numeric size of the object that was to be drawn. We used the mnenonic "length" as a measure of the size of an object (or the distance between objects) when talking about designs and design problems with the children. The absolute size for a particular object was left to be determined when the procedure was executed.

The design sketch was used in one of two ways. Some individuals chose to write computer instructions working directly from the sketch. Others used the sketch as a guide to construct a model of the design using acetate representations of the objects they would use to build the design. An example of the use of these acetates is shown in Figure 2.

Procedure Production

Once a starting place in the design was chosen, successive Logo instructions were formed by specifying a command and tracking its effect in the design. Instructions were written in a workbook before they were entered into a computer. We supplied cardboard cutout "cursors" that fit the end of a pencil to facilitate the determination of required cursor movements. The acetate design elements were marked with the starting and ending cursor position and orientation.

Where appropriate, we introduced the use of multiplication and division operators with the "le gth" size representation. For example, if an individual required a square twice as large as another within a design we would suggest using the notation, 'length * 2' meaning, "the length times two". Division was introduced in a similar manner.

The children were expected to produce syntatically correct statements in their notebooks as they worked through the design. Each child created a "reminder-list" for the correct spelling and form for each Logo instruction they used.

When a procedure was complete, the statements were typed into the Logo editor, checked against the notebook copy and then executed. Whenever a procedure executed, the children were encouraged to compare the movement of the drawing cursor with their expectations, either recollected or recorded in their notebook. To enable this instruction-tracking, the speed of cursor motion had been slowed by means of software modifications. Any discrepancies, once identified were located in procedure text by referring to the original design sketch or to acetate models, constructed on the spot.

Procedure Completion

When a procedure was completed and verified, the children produced a printed copy of the text of the procedure with the resulting graphic image. These records provided the children with a computer version of a sketch-implementation record similar to that which they had written in their notebooks. Figure 3 is an example of such a record.

The children were encouraged to use the just-completed design in a number of ways. Because procedures were written to allow the specification of a size at execution time, we could ask for example, what would be the largest size for the figure that would fit on

the computer screen. Some procedures were developed specifically to be integrated into more complex designs, so that the production marked the end of one part of a larger design project. Designs produced in later workshops were more descriptive in nature (for example, "rocket", "airplane", "tree", etc.) and could be used to construct pictures on the screen. To assist these activities, we provided a procedure to position the drawing cursor at one of seven locations on the screen. This "start" procedure was incorporated into the text of more complex productions.

Some of the preparation for picture-construction activities was done directly onto the computer screen. In this case the children were using their own Logo procedures as a part in the planning stage of a new design. Figure 4 shows a completed picture production.

Production Assessment

A major problem in Logo research involves the description of individual performance. If performance using Logo is to be related to other measures, some metric is needed.

We are using a simple additive "point" score calculated for each individual's productions as a representation of summative performance. The score gives equal weight to each occurrence of the elements of the Logo language in a production. An equal weight scheme is used since we have no a priori reason to attribute more weight to one than to another element at this stage in our instructional development. Scores are meant to represent performance for the sequence of workshop sessions during which a production was created.

The score consists of the sum of single points for; a) each movement operator, b) each arithmetic operator and, c) correct procedural syntax, d) the number of instructions in the procedure. Single points are subtracted for improper procedural syntax or inappropriate statement usage. Examples of the scoring for three Logo procedures is shown in Figures 5 and 6. We are reporting elsewhere (Cameron, in preparation) a significant relation between our procedure score and Piaget's measure of horizontal-vertical coordination. Figure 7 shows the distribution of procedure scores and includes a second measure, the ratio of number of statements to the number of procedures for each individual who completed the problem-solving workshops.

To: all plane : Length

Stack 5 : Length

Repeat 5 [Stack : Length]

Right 10

Repeat 2 [Forward : length]

Right 90 : Right 180

Right 90

Stack 3 : Length

Right 90

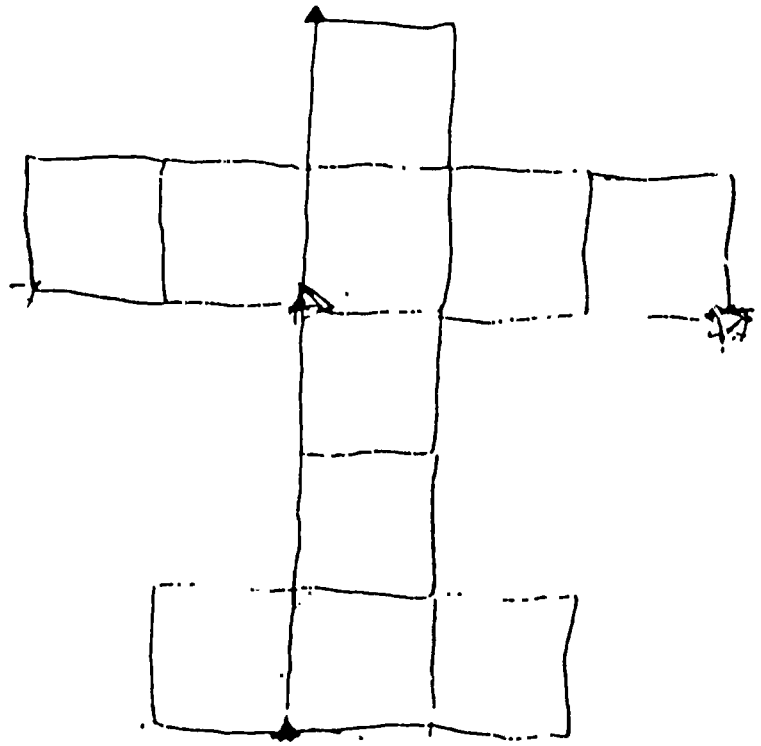
Forward : Length

Right 90

Forward : Length

Left 90

Repeat 2 [Forward Length]



Right 90

Repeat 3 [Forward 1 : Length] Finish

Right 90 Right

Right 90

Stack 5 : Length

Figure 1

Figure 2

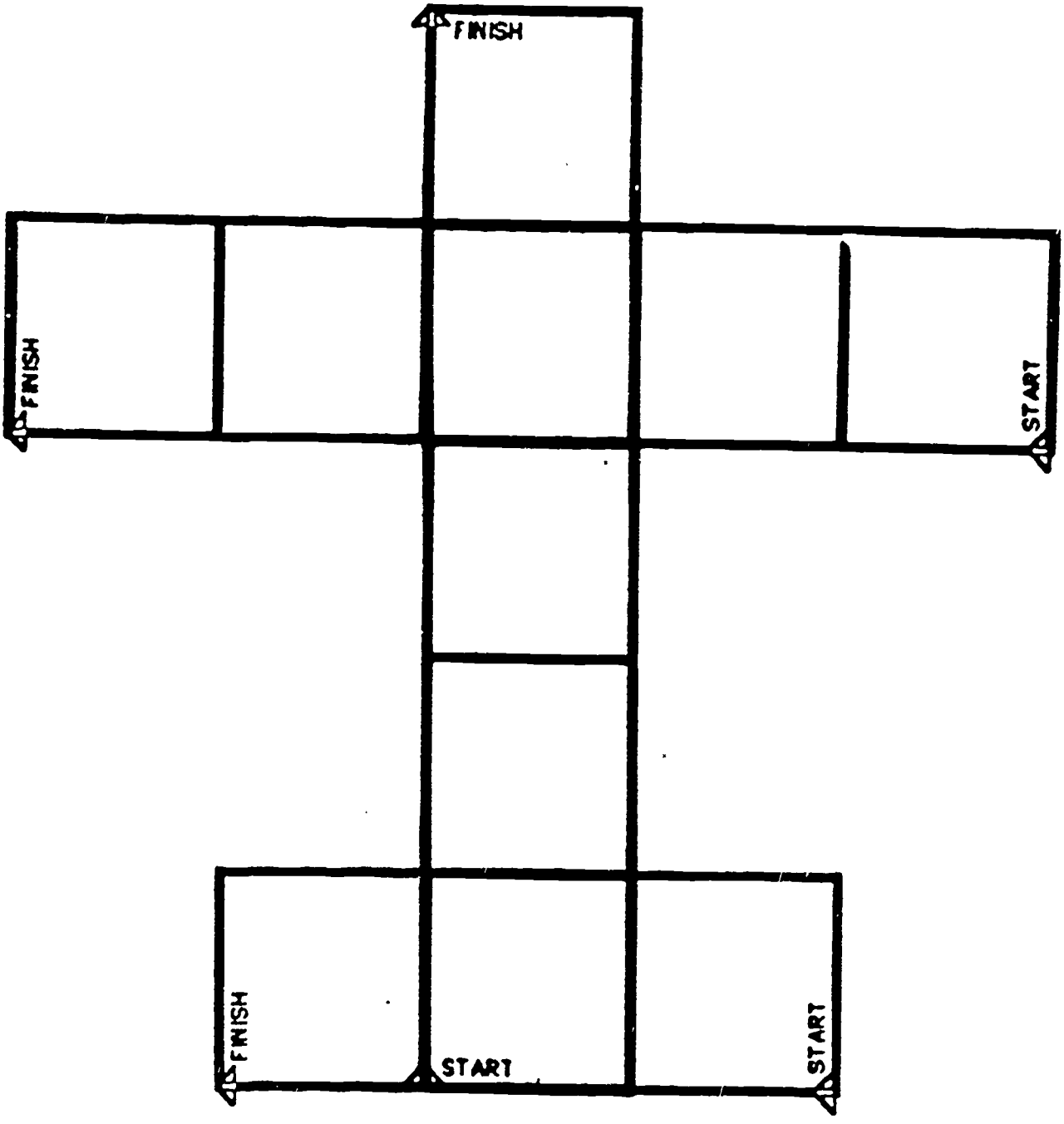
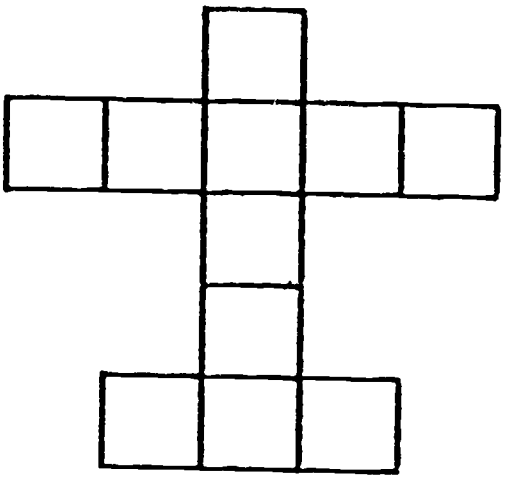


Figure 3



```
TO AIRPLANE :LENGTH
STACI 5 :LENGTH
REPEAT 5 [BACI :LENGTH]
RIGHT 90
REPEAT 2 [FORWARD :LENGTH]
RIGHT 180
STACI 3 :LENGTH
RIGHT 90
FORWARD :LENGTH
RIGHT 90
FORWARD :LENGTH
LEFT 90
REPEAT 2 [FORWARD :LENGTH]
RIGHT 90
REPEAT 3 [FORWARD :LENGTH]
RIGHT 180
BACK 5 :LENGTH
END
```


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Figure 4

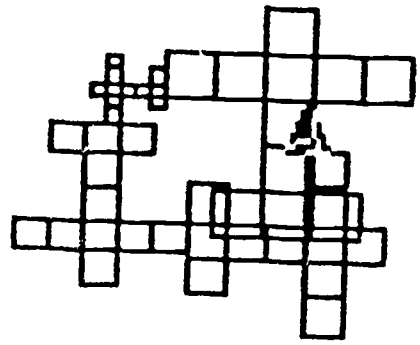

Figure 5

Statement	Scoring
To plane	-1
back 15	1
stack 8 15	1
triangle 15	1
back 15	
right 90	1
repeat 3 [back 15]	1
stack 7 15	
repeat 4 [back 15]	
left 90	1
repeat 6 [back 15]	
right 90	
repeat 2 [back 15]	
stack 5 15	
End	

Line count 13
Total score for plane 18

To L :length	1
stack4 :length	1
repeat 2 [back :length]	2
right 90	1
stack4 :length	
End	

To stack4 :length	1
square :length	1
forward :length	1
square :length	
forward :length	
square :length	
forward :length	
End	

Line count 10
Total score for L and stack 18

```
To train :length                1
start "g                        1
car.b :length                   1
top2 :length                    1
top1.c :length                  1
hitch :length                   1
car.b :length
top2 :length
hitch :length
car.b :length
top3 :length                    1
End

To top2 :length                 1
triangle :length                1
right 90                        1
forward :length                 1
left 90                         1
triangle :length
End

To top1.c :length               1
penup                           1
forward :length                 1
pendown                         1
left 90                         1
forward :length / 2             1
right 90                        1
triangle :length                1
left 60
stack 2 :length / 2             1
triangle :length / 2
back :length                    1
right 60                        1
penup
back :length
right 90
forward :length / 2
left 90
pendown
```

```
To car.b :length                1
right 90                        1
stack 2 :length                 1
right 90
forward :length                 1
right 90
forward :length / 2             2
penup                           1
left 90                         1
forward :length / 2
pendown                         1
circle :length / 2              1
right 90
penup
forward :length
pendown
circle :length / 2
penup
forward :length / 2
forward :length
End

To hitch :length                1
right 90                        1
forward :length                 1
right 90
forward :length / 2             1
left 90                         1
forward :length / 2
left 90
forward :length / 2
End
```

```
To top3 :length                 1
triangle :length / 2            2
right 90                        1
forward :length / 2             1
left 90                         1
triangle :length / 2
right 90
forward :length / 2
left 90
triangle :length / 2
left 90
forward :length / 2
forward :length
right 90
penup                           1
forward :length / 2
pendown                         1
triangle :length
right 90
forward :length
left 90
triangle :length
left 90
forward :length / 2
penup
right 90
forward :length
pendown
triangle :length
End
```



```
Line count          88
Total score         46
```

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Figure 7

I.D.	Number of Procedures	Total Score	Procedure Density
LT	18	93	2.51
LF	14	83	1.86
PT	19	79	1.82
SS	11	61	2.38
SD	12	57	1.72
DG	13	52	3.83
HS	8	41	1.91
JH	8	35	2.67
IC	9	32	2.58
AA*	3	30	2.07
MR*	3	22	5.45

* Completed ten workshop sessions.